# LIGHTING RESEARCH PROGRAM

## CASE STUDIES

*Prepared For:*
**California Energy Commission**
Public Interest Energy Research Program

Arnold Schwarzenegger, *Governor*

CONSULTANT REPORT

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# CALIFORNIA ENERGY COMMISSION

***Prepared By:***
*International Facility Management Association*
Shari Epstein
*Lawrence Berkeley National Laboratory*
Francis Rubinstein

***Managed By:***
*Architectural Energy Corporation*
Judie Porter
***Program Director***
Boulder, CO
CEC Contract # 500-01-041

***Prepared For:***
Michael Seaman
***Contract Manager***

Ann Peterson
***PIER Buildings Program Manager***

Nancy Jenkins
***Office Manager***
**ENERGY EFFICIENCY RESEARCH OFFICE**

Martha Krebs, Ph.D.
***Deputy Director***
**ENERGY RESEARCH AND DEVELOPMENT DIVISION**

B. B. Blevins
***Executive Director***

# Hotel Bathroom Lighting Control System

***"A real win-win with 50% savings, reduced maintenance, fewer customer complaints!"***

– Bob Hughes, DoubleTree Hotel Director of Operations



## Energy Savings Opportunity

Many hotel bathroom lights operate during unoccupied times, wasting electricity, and increasing maintenance costs. Research has shown that many guests do not turn off the bathroom lights when they leave their room and more than 40% use the bathroom light as a nightlight.

As Lawrence Berkeley National Laboratory (LBNL) lighting researcher Michael Siminovitch found, "More than 75% of the energy used by these fixtures occurs when bathroom fixtures are left on for more than two hours at a time and most often during the overnight hours."

The Watt Stopper Inc., LBNL, and the Sacramento Municipal Utility District (SMUD) partnered in research to develop a Bathroom Lighting Control System, the WN-100 Motion Sensor Nightlight, to address the inefficient use of hotel bathroom lighting.

The result is a wall-mounted light switch with a built in occupancy sensor and an LED nightlight. While these technologies are not new, the WN-100 Motion Sensor Nightlight combines them in an innovative system which saves electricity and decreases maintenance costs.

## DoubleTree Hotel Test Site

The DoubleTree Hotel in Sacramento, California was chosen as a test site for the new WN-100 Motion Sensor Nightlight technology. Staff electricians replaced 448 standard wall switches with the new sensors. Prior to installation, LBNL researchers measured the light usage in 15 guest bathrooms for two months to establish baseline usage. The researchers then monitored the same bathrooms for two months after installation to quantify energy savings.

## WN-100 Motion Sensor Nightlight Highlights

**Energy Savings**
Minimizes lighting overuse and achieves 50% energy savings!

**Operation & Maintenance**
Cuts O&M costs by 33% by reducing lighting use, resulting in extended lamp life and fewer burned-out lamp complaints!

**Occupant Comfort & Safety**
Supports nighttime vision with energy saving, low-level LED illumination.

| | |
|---|---|
| **Manufacturer:** | The Watt Stopper Inc. |
| **Market:** | Widespread application in hotel bathrooms, military housing, and healthcare facilities. |
| **Site:** | DoubleTree Hotel in Sacramento, California |

## Installation-related Costs

*New Construction:* The WN-100 Motion Sensor Nightlight requires the same labor to install as any wall mounted switch and costs $38 per device when purchased in large quantities.

*Retrofit:* The Watt Stopper Inc. estimates that installation requires about one half hour, costing about $68 per room using a standard electrician rate of $60/hr and a cost of $38 for the device.

## Payback

Providing night lighting and occupancy-based lighting control, the WN-100 Motion Sensor Nightlight delivers both energy and non-energy benefits. Using the above costs, the simple payback from energy savings alone was calculated to be 5½ years for retrofits and 2½ years for new construction using 64W bathroom luminaires. At the DoubleTree Hotel, as lamp usage decreased, so did energy use, lamp replacement, and customer complaints. Facility managers estimated that the product reduced operation and maintenance costs by 33%, further shortening the payback by as much as a year.

## Study Results

The DoubleTree's pre- and post-installation data shows a 50% reduction in energy use! As expected, most savings occurred from 10:00pm to 3:00am and from 7:00am to 1:00pm supporting previous findings that bathroom lights frequently operate during unoccupied times and are used as nightlights.

The DoubleTree study achieved the following significant cost savings:

- Number of Rooms 448
- Retro-fit cost per Room ~$45 (including utility incentive)
- Project cost ~$20,000 (including labor)
- Annual energy savings ~ 66,500 kWh
- Annual cost savings ~ $8,000
- **Simple payback ~ 2.5 years**

Equally impressive were the non-energy cost savings resulting from decreased lamp replacement and associated O&M maintenance. Lamp replacement costs were reduced from ~$1500/month to ~$1000/month, a 33% reduction resulting in an additional $6000/year savings!

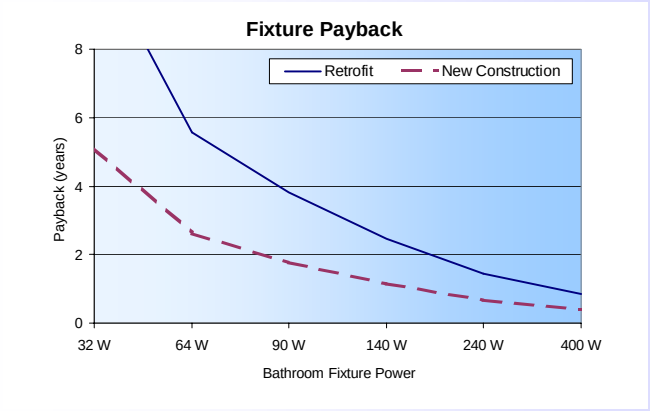


*Figure 1-Simple payback in years for new and retrofit applications, assumes $0.14/kWh, not including O&M savings.*

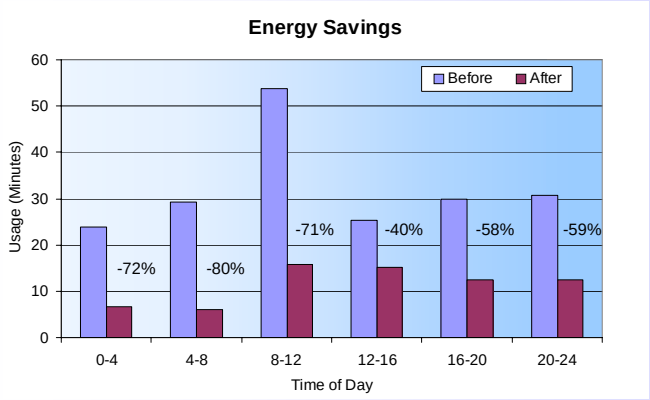


*Figure 2- Average energy reduction in a typical room before and after retrofit. The greatest savings are seen between 8 a.m. and 12 p.m. when occupants vacate the room and leave the lights on.*

## Conclusion

At the Sacramento DoubleTree Hotel, the WN-100 demonstrated significant electricity and O&M cost savings, resulting in a two and a half year payback. The nightlight feature was well received, with no complaints on the customer comfort questionnaires and a number of positive responses specifically mentioning the added comfort provided by the nightlight. By installing the WN-100 Motion Sensor Nightlight, the DoubleTree Hotel reduced bathroom luminaire energy use by 50%, reduced customer complaints, and decreased O&M costs.

## Availability

The Motion Sensor Nightlight is currently being offered for sale through The Watt Stopper catalog (www.wattstopper.com). The expected retail cost is $58 per individual unit or approximately $38 per unit for large volume purchases. Utility incentives may also be available.

# About PIER

This project was conducted by the California Energy Commission's Public Interest Energy Research (PIER) program. PIER supports public-interest energy research and development that helps improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

**For more information see** www.energy.ca.gov/pier


093005
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# Integrated Classroom Lighting System

***"Without hesitation, I would recommend this lighting system to other school districts!"***

– Dr. Kelvin Lee, Superintendent Dry Creek School District



## Energy Savings Opportunity

Lighting typically represents 20% of the total energy use in a K-12 school. By reducing the connected lighting load and giving teachers more control of the lighting system, significant energy savings can be realized while providing a higher quality of light.

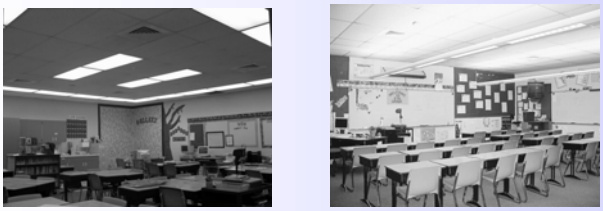
The Integrated Classroom Lighting System (ICLS) developed by Finelite combines a high performance direct-indirect light fixture with three high-efficiency Super T8 lamps. General-purpose classroom illumination (~0.95 W/sf) is achieved using 2 of the 3 lamps in the direct-indirect lighting fixture producing approximately 75 percent up-light and 25 percent down-light. An Audio/Video (A/V) or reading mode provides 3 percent up-light and 97 percent downlight using only a single down-light with optional dimming to 5 percent output. In the A/V mode, light levels on the ceiling and walls are reduced while an appropriate light level (~30 fc) is maintained on the student's desk.

The ICLS delivers 25 percent more light per watt than standard T8 fixtures due to a new 96 percent reflective coating combined with Super T8 lamp and ballast technology. In addition, the ballast factor can be selected to keep the connected load to **less than one watt per square foot.**

## Heritage Oaks School Test Site

Systems were installed in five classrooms at the Heritage Oaks School located in Roseville, California. This installation was one of 20 California sites, including a test classroom at Finelite and 14 additional classrooms at five other schools. Researchers tested for energy savings, occupant comfort, and overall system performance.

Four of the Heritage Oaks classrooms had retrofits with the ICLS lighting fixtures. Two of the classrooms had two rows of ICLS fixtures (one with A/V dimming, one without) with a 1.18 ballast factor. The other two classrooms had three rows of ICLS fixtures (with and without A/V dimming) using a 0.77 ballast factor. The control classroom retained the pre-retrofit lighting system, 26 two-lamp T8 recessed parabolic troffers.



*The pre-retrofit classroom system is shown on the left with lensed troffers. The new ICLS system is shown on the right.*

**Product:** Series 10 Integrated Classroom Lighting System (ICLS)

**Manufacturer:** Finelite Inc.

**Market:** Schools, conference and multi-purpose rooms found in commercial facilities, churches, and government buildings

**Site:** Heritage Oaks School

## Payback

The cost of the classroom retrofits at Heritage Oaks was $2600 for the two-row without dimming and approximately $3100 with A/V dimming control. The third row of light fixtures cost an additional $1100. The ICLS retrofit using occupancy sensors resulted in energy savings averaging more than 50%, which based on 7 months of data translate into nearly $500 savings annually per room ($0.14/kWh, 200 days per year). The resulting payback period was a minimum of 6.5 years for two rows of fixtures and a maximum of 9.6 years for three rows with A/V dimming control.

**Heritage Oaks School Retrofit Payback Period**

| | Average Daily Use (kWh) | Estimated Annual Use (kWh) | Estimated Annual Cost ($) | Estimated Annual Savings ($) | Initial Cost ($) | **Retrofit Payback (yrs)** |
|---|---|---|---|---|---|---|
| Base Case (26 Parabolics) | 26.6 | 5318 | $745 | $0 | $0 | **--** |
| ICLS 2 Rows, No A/V Dim* | 12.3 | 2469 | $346 | $399 | $2,600 | **6.5** |
| ICLS 2 Rows, with A/V Dim* | 11.4 | 2284 | $320 | $425 | $3,100 | **7.3** |
| ICLS 3 Rows, No A/V Dim* | 11.0 | 2191 | $307 | $438 | $3,700 | **8.4** |
| ICLS 3 Rows, with A/V Dim* | 10.9 | 2185 | $306 | $439 | $4,200 | **9.6** |

* Includes Occupancy Sensor

For new construction, the installed cost of the ICLS (~$2.71 / sq ft) is less than the cost of a typical layout using 15 parabolic troffers (~$2.86 / sq ft.). The maximum connected load for the ICLS is approximately 0.95 watts per square foot compared to 1.35 watts per square foot for more typical designs. The reduced lighting load combined with no additional first cost yields an instant payback! Installing the optional upgrade of A/V dimming still results in a payback of 2 years while a third row of fixtures has a longer payback (8.1 years), assuming $0.14/kWh and 200 days/yr.

**New Construction Estimated Payback Period**

| Alternative | LPD (W/sq ft) | Installed Cost ($/sq ft) | Installed Cost ($) | Cost Difference ($) | Cost Savings ($/yr) | Simple Payback (yrs) |
|---|---|---|---|---|---|---|
| 15 Parabolics (typical) | 1.35 | $2.86 | $2,745 | $0 | $0 | -- |
| **ICLS 2 Rows, No A/V Dim*** | **0.93** | **$2.71** | **$2,600** | **-$145** | **$106** | **Instant!** |
| ICLS 2 Rows, with A/V Dim* | 0.73 | $3.23 | $3,100 | $355 | $176 | 2.0 |
| ICLS 3 Rows, No A/V Dim* | 0.95 | $3.86 | $3,700 | $955 | $118 | 8.1 |
| ICLS 3 Rows, with A/V Dim* | 0.75 | $4.38 | $4,200 | $1,455 | $168 | 8.6 |

* Includes Occupancy Sensor

## Study Results

Overall system performance was determined through energy usage data and an occupant comfort survey. Daily energy savings ranged from a minimum of 35% to a maximum of 75%, and averaged over 50% for the entire year for all four ICLS installations.

Most of the savings (~80%) were the result of the reduction in the connected lighting load from 1.8 to 1.0 W/sf. Additional savings (~20%) were the result of allowing teachers more control of the lighting system and providing occupancy sensors. The daily energy savings were clearly demonstrated for all four of the ICLS rooms (**see Figure 1**).

In the occupant surveys, teachers showed a preference for the three row ICLS over the two row. Increased lighting levels on all walls as well as on the teacher desktop were the most noted benefits of the three row system. Foot-candle measurements showed lower overall levels directly beneath the fixtures, 88 fc for three rows compared to 111 fc for two rows. Whereas, measurements showed increased illuminance near the walls, 30 fc for three rows compared to 22 fc for two rows. These light levels were achieved using the same W/sf in both cases by selecting lower ballast factors in the three row system.

The teacher comfort survey showed teacher preference for the ICLS compared to the typical lensed troffer lighting system (**see Figure 2**). The ICLS reduced glare and eye fatigue while increasing perceived light levels on all teaching surfaces. In addition, the teachers integrated the A/V downlight mode into their daily instruction with great success, switching lighting modes to change the learning environment.

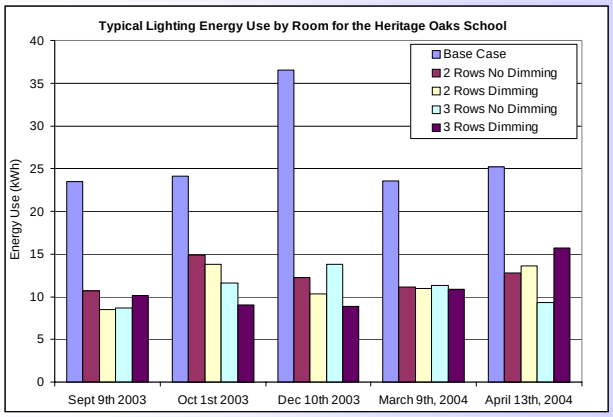
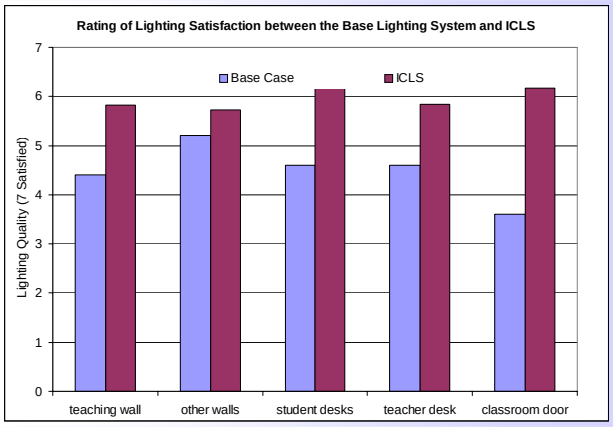



*Figure 1 (above) -ICLS energy use compared to a lensed troffer lighting system. Energy savings vary seasonally. Greatest savings were realized during the winter.*

*Figure 2 (below) -Teacher satisfaction for a typical lensed troffer lighting system and the ICLS. The ICLS lighting increases satisfaction by providing a better distribution of light, and has a connected load of only 1.0 W/sf.*




"The lights at first I felt were too dim, however over time I realized the previous ones were just too bright! These lights seem to be more natural and less harsh on the eyes."

-Heritage Oaks Teacher

## Conclusion

The Integrated Classroom Lighting System test site at Heritage Oaks School demonstrated energy savings of more than 50% and teacher preference for the ICLS. The energy savings were realized by reducing the connected lighting load and giving teachers more control of the lighting system while providing a higher quality of light. The cost savings resulted in payback periods that ranged from 6.5 years to 9.6 years. In new construction applications, the ICLS provides greater energy savings, better control, and higher quality light to important surfaces for an installed cost less than a typical lensed troffer system.

## Availability

The Series 10 Integrated Classroom Lighting System (ICLS) is currently being offered for sale through Finelite. To purchase or learn more about the system, visit the Finelite web site (www.finelite.com).

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# Bi-level Stairwell Lighting

***"Bi-level lighting has a lot of energy savings potential. Over 60% energy savings and no complaints!"***

–Paul Black, UC Berkeley Manager of Utilities Engineering



## Energy Savings Opportunity

Stairwell lighting typically operates continuously at full output despite very low, intermittent use. A bi-level product line developed by LaMar Lighting uses an ultra-sonic motion sensor to detect motion in stairwells and corridors, and solid state controls are used to dim fixtures to lower light levels when a space is unoccupied. This product is ideal for areas where codes, user preferences, safety, or security requirements call for minimal light levels during unoccupied periods and full light output during occupied periods.

A preliminary study sponsored by the New York State Energy Research and Development Authority tested the technology and showed less than 4% occupancy of stairwells at two monitored sites with energy savings of 53% to 60% using bi-level fixtures that dim to 33% during unoccupied periods. Depending on the fixture configuration, the technology decreases light output from full output to 5%, 10% (120V only), or 33%. Thus, power in a typical two lamp 32 W T8 fixture is reduced from 64 W to 7–28 W.

Currently, most building codes require minimal lighting of 1 foot-candle (fc) for emergency egress in all staircases. However, a new ANSI standard has been proposed that would increase the required amount of light in stairwells during occupancy from the current standard of 1 fc to 10 fc on the stair tread or landing. To mitigate the increase in energy costs that would accompany such a requirement, these codes would also allow the use of bi-level lighting technology to reduce stairwell light levels back to 1 fc during unoccupied periods.

## UC Berkeley Test Site

Researchers replaced 23 2-lamp 40 W T12 fixtures with 2-lamp 32 W T8 bi-level lighting fixtures in one stairwell at Evans Hall on the UC Berkeley campus, which is a 10-story math building with multiple stairwells. Lighting levels provided by the old fixtures ranged from 0.8 to 11 fc. Post-retrofit light levels ranged from 6 to 11 fc at 100% and around 1fc in standby mode.

## Highlights

- 63% annual energy savings
- Three times the energy savings of a typical T8 retrofit
- 3.8 year payback
- Higher quality lighting

**Product:** Occu-smart® Series
**Manufacturer:** LaMar Lighting Inc.
**Market:** Stairwells, storerooms, restrooms, and laundry rooms
**Site:** Evans Hall, University of California Berkeley

## Payback

The northeast stairwell of Evans Hall was retrofit with 23 2-lamp 32 W T8 Voyager bi-level fixtures for a total installed cost of $5,450. Extrapolating 4 months of monitored data for an entire year, the bi-level lighting retrofit results in annual savings of $1,430 per year compared to the old system, yielding a payback of less than 4 years (assuming $0.14/kWh).

In comparison, a standard lighting retrofit (i.e. typical 2-lamp 32 W T8 with no bi-level capabilities) would have a payback of 5.5 years, assuming $60 for a new fixture and $50 for installation.

**Evans Hall Payback**

| | Energy Use (kWh/yr) | Energy Savings (kWh/yr) | Fixture Cost ($) | Installation Cost ($) | Total Cost ($) | Annual Cost ($) | Annual Savings ($) | **Evans Hall Payback (yrs)** |
|---|---|---|---|---|---|---|---|---|
| No retrofit | 16,120 | -- | $0 | $0 | $0 | $2,260 | $0 | **-** |
| Strandard retrofit | 12,890 | 3,230 | $1,380 | $1,150 | $2,530 | $1,800 | $460 | **5.5** |
| Bi-level retrofit | 5,910 | 10,210 | $4,300 | $1,150 | $5,450 | $830 | $1,430 | **3.8** |

* Fixture costs were $187; installation time was approximately 30 minutes and estimated to cost $50.

For new construction, the predicted payback period is between 2 and 8 years depending on the fixture wattage of the alternative and the bi-level dimming capacity selected (5%, 10%, or 33%). Using a utility rate of $0.14/kWh, analysis shows:

**New Construction Payback**

| Bi-Level Dimming Configuration | Standard Fixture Power (W) | Bi-level Fixture Power (W) | Bi-level Standby Power (W) | Estimated Time in Standby (%) | Average Bi-level Power (W) | Average Energy Saved (W) | Annual Energy Savings (kWh/yr) | Annual Cost Savings ($) | Added Cost Bi-level ($) | **New Payback (yrs)** |
|---|---|---|---|---|---|---|---|---|---|---|
| Dim to 5% at | 62 | 62 | 13 | 95% | 15.5 | 75 | 650 | $91 | $187 | **2.1** |
| Standby | 62 | 62 | 13 | 95% | 15.5 | 47 | 410 | $57 | $187 | **3.3** |
| (120V or 277V) | 32 | 32 | 8 | 95% | 9.2 | 23 | 200 | $28 | $187 | **6.7** |
| Dim to 10% at | 62 | 62 | 13 | 95% | 15.5 | 75 | 650 | $91 | $172 | **1.9** |
| Standby | 62 | 62 | 13 | 95% | 15.5 | 47 | 410 | $57 | $172 | **3.0** |
| (120V only) | 32 | 32 | 8 | 95% | 9.2 | 23 | 200 | $28 | $172 | **6.2** |
| Dim to 33% at | 62 | 62 | 28 | 95% | 29.7 | 60 | 530 | $74 | $163 | **2.2** |
| Standby | 62 | 62 | 28 | 95% | 29.7 | 32 | 280 | $39 | $163 | **4.2** |
| (120V or 277V) | 32 | 32 | 14 | 95% | 14.9 | 17 | 150 | $21 | $163 | **7.8** |

## Study Results

Total energy savings for Evans Hall were calculated by recording the amount of time the fixtures were in standby mode (dimmed to 5%). Four months of data demonstrated that, on average, the fixtures were in the standby mode 68% of the time.

**Figure 2** shows the average variation in bi-level lighting usage between floors. Usage patterns also differed from weekends to weekdays. Extrapolating four months of data to an entire year showed the bi-level fixture will save 10,210 kWh/yr, a 63% energy savings, or roughly **three times greater energy savings than a typical T8 lighting retrofit!** (**see Figure 3**)

In general, energy savings for bi-level fixtures depend on stairwell occupancy and the step-down settings. A comparison of energy savings at Evans Hall and three other California office buildings with similar bi-level retrofits show the greatest energy savings at Evans Hall (**see below table**).

The other three sites were in occupied mode less than 25% of the time but showed less than 50% energy savings. The sites used bi-level fixtures that dimmed to 33% compared to 5% at Evans Hall.

**Bi-Level Fixture Energy Savings for Four Buildings**

| Building | Occupied (%) | Standby Mode (%) | **Energy Savings (%)** |
|---|---|---|---|
| Evans Hall | 32% | 68% | **63%** |
| Chiron Building M | 25% | 75% | **42%** |
| Alameda County Office | 11% | 89% | **46%** |
| SBC Office | 18% | 82% | **38%** |

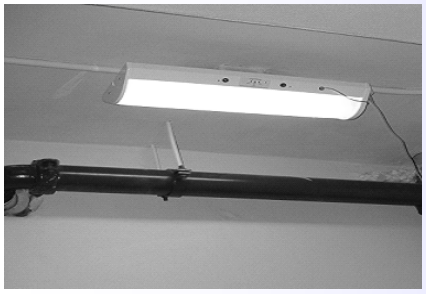


*Figure 1- Example of the bi-level stairwell fixture.*

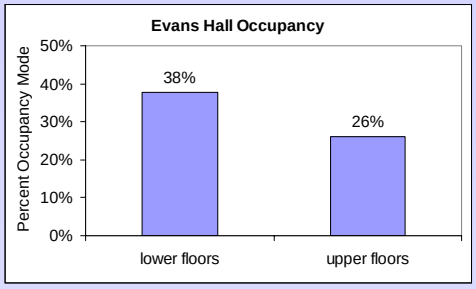
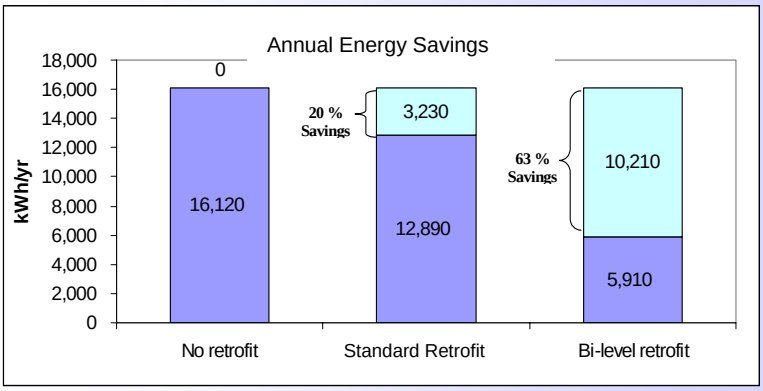



*Figure 2-The percent time bi-level fixtures were in the occupied mode for upper and lower floors.*




**Energy Use Comparison Between Retrofits**

| | Percent Full | Percent Standby | Number of Fixtures | Watts Full (W) | Watts Standby (W) | Energy Use (kWh/yr) | Energy Savings (kWh/yr) | **Energy Savings (%)** |
|---|---|---|---|---|---|---|---|---|
| No Retrofit | 100% | 0% | 23 | 80 | n/a | 16,120 | -- | **0%** |
| Standard Retrofit | 100% | 0% | 23 | 64 | n/a | 12,890 | 3230 | **20%** |
| Bi-level Retrofit | 32% | 68% | 23 | 64 | 13 | 5,910 | 10210 | **63%** |

*Figure 3- Shows the annual energy savings for the bi-level retrofit at Evans Hall compared to a standard T8 lighting retrofit. The table below the figure summarizes the data.*

## Conclusion

Using bi-level stairwell lighting clearly demonstrated a dramatic reduction in energy use at Evans Hall. Replacing old T12 fixtures with the bi-level fixtures resulted in 63% energy savings and a payback of less than 4 years. The fixtures were in the standby mode 68% of the time. The potential for energy savings is even higher in office buildings where stairwell usage is primarily limited to high traffic times. Bi-level stairwell fixture technology is designed to provide safe, reliable, and efficient lighting with high illumination during occupied periods and reduced illumination when stairwells are vacant.

## Availability

The Occu-smart® Series bi-level light fixtures are currently being offered for sale through LaMar Lighting. To purchase or learn more about the system, visit the LaMar Lighting web site (www.lamarlighting.com).

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